multiple arms, having either grasping jaws, suction cups or sculptured mechanical nests, adapted for receiving the molded paired Rx lenses that have molded-on hanger tabs. An especially preferred embodiment employs the SCARA robot to precisely place the head of the hanger tab into a substantially mechanically mating geometry (preferably with a tapered lead-angle fit) nest of the type shown in FIG. 3B, and located near the end of each of these arms.

A further optional but preferred embodiment of this special type of curing workstation would then allow for a settable rotation of the arm, such that the position of the molded, paired Rx lens can be varied from a "straight down" vertical orientation (wherein the molded, paired lenses hanging vertically direct down from the arm, at a 90-degree angle), and by rotation of the arm, this angle can be successively reduced to some minimal angle of perhaps 10 degrees or so below the horizontal orientation. (See FIG. 3B, retention step (58)) This optional, but preferred, embodiment has the advantage of employing gravity to create a more uniform coating flowout pattern distributed all across the lens surface. This is believed to be especially important for those Rx lenses having strong plus powers (steep, convex front curved surfaces), and also multi-focal lenses having a ledged bifocal or trifocal segment ("D seg"). Those two types of lenses are particularly problematical when the coating is dried and cured in a substantially vertical orientation due to gravity then increasing the nonuniformity of flowout of the liquid hardcoating. Refer to Weber (U.S. Pat. No. 4,443,159) coating patent.

E. Process Flowsheets for Add-On Steps in Continuous-Process, following "Mold and Dipcoat"

In yet another optional but preferred embodiment, after the molded and hardcoated lenses are cured at least to a tackfree state, the lenses are then robotically transferred into an adjoining extension of the same cleanroom enclosure which contains an automated computer-assisted-vision lens inspection system, for cosmetic inspection. See FIG. 4C. Such automated lens inspection machines typically use pattern recognition computer software with a video and/or laser-scanning noncontact inspection, and make comparison of the resulting image against the computer's decision rules for "go" and "no-go" acceptance of any cosmetic flaw deviations. However, such an optical computerized inspection system for cosmetics relies upon high-resolution imagery and a large proportion of all cosmetic rejects are at the surface of the hardcoated lenses ("coating clear specks" and "coating flowout runs", especially). One such manufacturer of Rx FSV lens automated inspection machines is Non-Contact International, of Maumee. Ohio.

Such inspection system in giving desired results (i.e., rejecting bad lenses and accepting good lenses) must not reject "good" lenses which only have a lightly-held dust particle laying loosely on the lens surface. Cleanliness of the lenses coming into the inspection system is the biggest problem in its use so far. Elaborate and costly multi-stage cleaning equipment workstations and protocols have been necessitated to properly use such equipment. A particularly advantegeous combination of the present invention with such machines would employ this mated cleanroom (so the lens never leaves the Class 100 clean air environment) operating with positive pressure without any human operator within that airspace, so that paired tackfree-hardcoated lens are kept in a pristine state as they leave the curing workstation directly to the video inspection station. Cosmetic rejects caught at this tackfree state can then be robotically set aside and recycled through solvent stripping, re-cleaning, and re-dipcoating, as mentioned earlier.

See flowsheet of FIG. 4D. Yet another optional but preferred embodiment of the present invention takes the hardcoated lens to full crosslinked state before leaving the curing workstation, then robotically transfers the molded fully-cured hardcoated paired Rx lens within an adjoining extension of this mated clean-room enclosure maintained under positive pressure (HEPA-filtered air of typically Class 100 purity), wherein this connected-clean-room enclosure contains a thin-film anti-reflective ("AR") vacuum-coating machine fitted with multiple load locks and product workholders adapted to the molded, hardcoated, paired lenses. FIG. 4D shows a block diagram flowsheet of the present invention's steps, within a single cleanroom enclosure (designated by the dashed-line, showing all steps are performed within its cleanroom airspace perimeter). This continuous-process anti-reflective vacuum coating system would typically contain the following steps:

1. After the load station, pull at least a rough vacuum before transferring to a second vacuum stage via load lock, wherein a final vacuum is pulled.
2. At that point, some surface preparation protocol, such as ionizing plasma or electron gun discharge, can be used to clean and/or modify surface chemistry of the top few molecular layers of the hardcoated Rx lens, either in this chamber or in the next chamber connected by load lock.
3. Once such surface preparation is completed, robotic transfer via load lock moves the paired lens into the vacuum-deposition chamber, wherein an AR film is deposited. Preferably, a high-arrival-energy type AR film is deposited by sputtering or by ion-gun-assist, so as to provide a desirably-dense-and strongly-adherent coating AR film onto one or both optical surfaces of the hardcoated paired lens.

Such a continuous-process automated-transfer AR-coating machine would be directly analogous to similar machines used by the hundreds for continuous-process aluminum-sputter-coating onto injection-molded polycarbonate compact discs. Leading vacuum-coating equipment manufacturers as Leybold, Balzers, and Denton Vacuum have provided such machines for integrated-molding-and-coating of compact discs (CDs).

We claim:

1. As an article of manufacture, thermoplastic injection molded paired spectacle lenses formed within a moldset having a parting line for opening between an A side and a B side of said moldset,

said paired lenses being suited as a unit of transfer in a multi-step automated manufacturing process comprising at least an automated demolding step, an automated liquid dip hardcoating step, and an automated drying and curing step,

said process being performed robotically within a cleanroom air enclosure, wherein said paired lenses are robotically handled from said demolding step through said dip hardcoating step and until said dip hardcoating has been dried and cured at least to a tackfree state within said cleanroom air enclosure,

said paired lenses comprising the elements of:

(a) two thermoplastic injection molded spectacle lens joined into a pair,

each of said lens having an outer perimeter forming a lens edge contoured for release out of a lens mold cavity,

said outer perimeter comprising four 90-degree quadrants defined in accordance with a clock face, wherein

an upper 90-degree quadrant is defined as being between 10:30 and 1:30 o'clock locations on the lens perimeter,

a lower 90-degree quadrant is defined as being between 4:30 and 7:30 o'clock locations on the lens perimeter,

a righthand side 90-degree quadrant is defined as being between 1:30 and 4:30 o'clock locations on the lens perimeter,

a lefthand side 90-degree quadrant is defined as being between 7:30 and 10:30 o'clock locations on the lens perimeter,

(b) a cold runner having a sprue connecting therebetween a left lens and a right lens in each pair, said cold runner being formed after molten thermoplastic flow from said sprue in fluid communication with said left lens and said right lens is stopped and then cooling to solidification joins together the lenses into a pair,

said cold runner being located in the righthand 1:30–4:30 o'clock side quadrant of the left lens and

said cold runner being located in the lefthand 7:30–10:30 o'clock side quadrant of the right lens,

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(c) an integrally-molded hanger tab located substantially equidistant between said right lens and said left lens of said paired lens,

said hanger tab having a stem rising substantially vertically out of said cold-runner connecting said paired lenses,

said hanger tab having a head located on said stem at a point above a highest lens edge when said paired lenses are held vertically in a dipping position, so as to prevent liquid dip hardcoating from contacting robotic means for gripping said head,

and said paired lenses formed within said moldset at the end of each molding cycle are robotically handled in the following process steps:

(i) ejecting cleanly off said B side of said moldset being opened along the parting line, said step of ejecting being initiated only when end-of-arm tooling of a takeout robot is in place to receive said paired lenses;

(ii) handling said paired lenses by automation within said cleanroom air enclosure without any human operators therein,

without any cold runner cutting step or any step of trimming of any tabs off the molded lens before dipcoating, and

without use of Freon CFC nor aqueous cleaning protocols before dipcoating;

(iii) dipcoating said paired lenses by said robotic means gripping said head while preventing liquid dip hardcoating from contacting said robotic means;

(iv) drying and curing after dipcoating said paired lenses at least to a tackfree state within said cleanroom air enclosure.

2. An article of claim 1 wherein said paired lenses are formed within multicavity injection-compression molds employing a variable volume mold cavity process.

3. An article of claim 1 wherein each of said lens having an outer perimeter forming a lens edge contoured for release out of a lens mold cavity,

and said lens edge has a positive draft angle formed on said B side.

4. An article of claim 1 wherein said cold runner having a sprue connecting therebetween a left lens and a right lens in each pair,

and said sprue has a cold well having negative controlled-draft-angle to grip said paired lenses onto said B side.

5. An article of claim 1 wherein each of said lens having an outer perimeter forming a lens edge contoured for release out of a lens mold cavity,

and said lens edge has an edge seal overlap on said A side.

6. An article of claim 1 having an additional element of

(d) one or more ejector tabs are employed,

said ejector tabs only being located along the lens perimeter so as not to interfere with proper dipcoating and not to propagate coating flowout runs, and none of such tabs being located in the upper quadrant.

7. An article of claim 1 having an additional element of

(d) one or more drip tabs are employed,

said drip tabs only being located along the lens perimeter in the bottom quadrant of each lens (4:30–7:30 o'clock positions), to minimize dipcoating dripmark size, by capillary wicking action to drain off excess liquid coating once the molded paired lens have been fully removed from immersion in the dipbath.

8. An article of claim 1 wherein said paired lenses are polycarbonate spectacle lens for vision correction.

9. An article of claim 1 wherein said takeout robot in place to receive said paired lenses upon ejection is of a side entry type, and modular blowers supplying HEPA-filtered air are located directly above platens of an injection molding machine within which said moldset is mounted, so as to maintain a positive-air-pressure within said cleanroom air enclosure which substantially surrounds said moldset.

10. An article of claim 9 wherein said side entry type takeout robot operates within a clean-room-enclosed tunnel between said moldset and an enclosed HEPA-filtered automated dipcoating machine.

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11. An article of claim 1 wherein after said takeout robot has received said paired lenses upon ejection, a step of cooling and removal of electrostatic charge of said paired lenses is performed before said step (iii) of dipcoating.

12. An article of claim 1 wherein said step of cooling and removal of electrostatic charge of said paired lenses is performed by immersion into a circulating filtered alcohol bath before said step (iii) of dipcoating.

13. An article of claim 1 wherein said step (iii) of dipcoating said paired lenses employs a programmable SCARA cylindrical type robot, as a second robotic device to grip said paired lenses by said hanger tab,

said programmable SCARA cylindrical type robot being fitted with jaws cut with a mating geometry for retaining said head of said hanger tab of said paired lenses, for gripping said head while preventing liquid dip hardcoating from contacting said robotic means.

14. An article of claim 13 wherein said step (iii) of dipcoating said paired lenses employing said programmable SCARA cylindrical type robot gripping said paired lenses by said hanger tab employs:

(a) a filtered circulating bath of liquid hardcoating of 2–10 centistoke viscosity;

(b) a withdrawal speed of at least 20 inches per minute.

15. An article of claim 14 wherein said step (iii) of dipcoating said paired lenses employing said programmable SCARA cylindrical type robot gripping said paired lenses by said hanger tab further employs:

(a) a filtered circulating bath of liquid hardcoating of 2–5 centistoke viscosity and formulated at less than 25% solids using mainly high-evaporation-rate solvents such as low molecular weight alcohols and ketones;

(b) a withdrawal speed of 0.5–5 inches per second;

(c) following a first dip with a second dip.

16. An article of claim 1 wherein said step (iv) of drying and curing after dipcoating said paired lenses at least to a tackfree state within said cleanroom air enclosure employs a rotary index drive fitted with a plurality of workholder arms,

each workholder arm being fitted with mating geometry for retaining said head of said hanger tab of said paired lenses,

operating as a carousel curing workstation.

17. An article of claim 1 wherein said a step of inserting said paired lenses into a lensholder rack within said cleanroom air enclosure employs said head of said hanger tab of said paired lenses for a spring interference fit for its mechanical retention means.

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18. As an article of manufacture, polycarbonate injection-compression molded paired spectacle lenses for vision correction formed within a variable volume multicavity moldset having a parting line for opening between an A side and a B side of said moldset,

said paired lenses being suited as a unit of transfer in a multi-step automated manufacturing process comprising at least an automated demolding step, an automated liquid dip hardcoating step, and an automated drying and curing step,

said process being performed robotically within a cleanroom air enclosure, wherein said paired lenses are robotically handled from said demolding step through said dip hardcoating step and until said dip hardcoating has been dried and cured at least to a tackfree state within said cleanroom air enclosure,

said paired lenses comprising the elements of:

(a) two polycarbonate injection-compression molded paired spectacle lens for vision correction joined into a pair,

each of said lens having an outer perimeter forming a lens edge contoured for release out of a lens mold cavity, and said lens edge has a positive draft angle formed on said B side,

said outer perimeter comprising four 90-degree quadrants defined in accordance with a clock face, wherein

an upper 90-degree quadrant is defined as being between 10:30 and 1:30 o'clock locations on the lens perimeter,

a lower 90-degree quadrant is defined as being between 4:30 and 7:30 o'clock locations on the lens perimeter,

a righthand side 90-degree quadrant is defined as being between 1:30 and 4:30 o'clock locations on the lens perimeter,

a lefthand side 90-degree quadrant is defined as being between 7:30 and 10:30 o'clock locations on the lens perimeter,

(b) a cold runner having a sprue connecting therebetween a left lens and a right lens in each pair, said cold runner being formed after molten thermoplastic flow from said sprue in fluid communication with said left lens and said right lens is stopped and then cooling to solidification joins together the lenses into a pair, and said sprue has a cold well having negative controlled-draft-angle to grip said paired lenses onto said B side,

said cold runner being located in the righthand 1:30–4:30 o'clock side quadrant of the left lens and

said cold runner being located in the lefthand 7:30–10:30 o'clock side quadrant of the right lens,

(c) an integrally-molded hanger tab located substantially equidistant between said right lens and said left lens of said paired lens,

said hanger tab having a stem rising substantially vertically out of said cold-runner connecting said paired lenses

said hanger tab having a head located on said stem at a point above a highest lens edge when said paired lenses are held vertically in a dipping position, so as to prevent liquid dip hardcoating from contacting robotic means for gripping said head,

and said paired lenses formed within said moldset at the end of each molding cycle are robotically handled in the following process steps:

(i) ejecting cleanly off said B side of said moldset being opened along the parting line, said step of ejecting being initiated only when end-of-arm tooling of a side entry takeout robot is in place to receive said paired lenses;

(ii) handling said paired lenses by automation within said cleanroom air enclosure without any human operators therein,

without any cold runner cutting step or any step of trimming of any tabs off the molded lens before dipcoating, and

without use of Freon CFC nor aqueous cleaning protocols before dipcoating;

(iii) cooling and removal of electrostatic charge of said paired lenses;

(iv) dipcoating said paired lenses with a programmable SCARA cylindrical type robot, as a second robotic device to grip said paired lenses by said hanger tab,

said programmable SCARA cylindrical type robot being fitted with jaws cut with a mating geometry for retaining said head of said hanger tab of said paired lenses, for gripping said head while preventing liquid dip hardcoating from contacting said robotic means, employing:

(a) a filtered circulating bath of liquid hardcoating of 2–10 centistoke viscosity;

(b) a withdrawal speed of at least 20 inches per minute

(v) drying and curing after dipcoating said paired lenses at least to a tackfree state within said cleanroom air enclosure,

employing a rotary index drive fitted with a plurality of workholder arms,

each workholder arm being fitted with mating geometry for retaining said head of said hanger tab of said paired lenses,

operating as a carousel curing workstation.

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